

LISTING OF THE CLAIMS

1. (Cancelled) A bipolar band-to-band infrared photodetector-diode, or laser diode, or light emitting diode, or amplifier, or electrooptic modulator-diode comprising
 - (a) a silicon substrate,
 - (b) a strain-relaxed $\text{Ge}_{1-y}\text{Sn}_y$ or $\text{Ge}_{1-y-z}\text{Sn}_y\text{Si}_z$ buffer layer upon Si, known as a virtual substrate, VS
 - (c) an active direct-bandgap region made up of a single-quantum-well heterostructure or a multi-quantum-well stack,
 - (d) a strain-relieved capping layer of $\text{Ge}_{1-y}\text{Sn}_y$ or $\text{Ge}_{1-y-z}\text{Sn}_y\text{Si}_z$ matching the VS composition,
 - (e) metallic electrical contacts to the Si substrate and/or capping layer.
2. (Cancelled) The devices of claim 1 wherein the substrate is doped N-type or P-type while the capping layer is doped P-type or N-type to form an NIP or PIN diode,
3. (Amended) [The devices of claims 1,2 wherein the VS is $\text{Ge}_{1-y}\text{Sn}_y$ and the active region is a strain balanced type-I stack of compressive $\text{Ge}_{1-2y}\text{Sn}_{2y}$ quantum wells with tensile Ge barriers.

A biopolar band-to-band infrared photodetector-diode, or laser diode, or light-emitting diode, or amplifier, or electrooptic modulator-diode comprising

(a) a silicon substrate, wherein the substrate is doped N-type or P-type while the bapping layer is doped P-type or N-type to form an NIP or PIN diode,

(b) a strain-relaxed $\text{Ge}_{1-y}\text{Sn}_y$ or $\text{Ge}_{1-y-z}\text{Sn}_y\text{Si}_z$ buffered layer upon Si, known as a virtual substrate, VS wherein the VS is $\text{Ge}_{1-y}\text{Sn}_y$ and the active region is a strain balanced type-I stack of compressive $\text{Ge}_{1-2y}\text{Sn}_{2y}$ quantum wells with tensile Ge barriers,

(c) an active direct-bandgap region made up of a single-quantum-well heterostructure or a multi-quantum-well stack,

(d) a strain-relieved capping layer of $\text{Ge}_{1-y}\text{Sn}_y$ or $\text{Ge}_{1-y-z}\text{Sn}_y\text{Si}_z$ matching the VS composition,

(e) metallic electrical contacts to the Si substrate and capping layer. — —

— — 4. (Amended) the devices of claims [1, 2,] 3 wherein the composition y ranges from 0.02 to 0.15 for device operation at wavelengths ranging from 1.55 to 5.00 μm . — —

— — 5. (Amended) the photodetector devices of claims [1,] 3, [4] in which the substrate is doped N or P type and the cap layer contact is an Schottky barrier metal. — —

— — 6. (Amended) the photodetector devices of claims [1,] 3, [4] in which the substrate is undoped and an interleaved pair of metal electrodes is employed upon the cap layer. — —

-- 7. (Amended) The devices of claims [1, 2] v^3 wherein the VS is $\text{Ge}_{1-y}\text{Sn}_y$ and the active region is an unsymmetrically strained type-II heterostructure with holes confined in a tensile Ge layer and electrons confined in the relaxed buffer layer. --

-- 8. The devices of claims [1, 2] v^3 wherein the VS is $\text{Ge}_{1-y-z}\text{Sn}_y\text{Si}_z$ and the active region is an unsymmetrically strained type-I heterostructure with electrons-and-holes confined in a tensile Ge layer. --

9. (Original) the devices of claim 8 wherein y and z are approximately 0.2.

10. A unipolar intersubband long-wave-infrared photodetector-diode, or laser diode, or light emitting diode, or amplifier, or electrooptic modulator diode comprising:

(a) silicon substrate

(b) strain-relaxed $\text{Ge}_{1-y}\text{Sn}_y$ buffer layer upon Si, known as a virtual substrate, VS

(c) an active direct-bandgap region made up of a strain-balanced type-I multi-quantum-well stack which has compressive $\text{Ge}_{1-2y}\text{Sn}_{2y}$ wells and tensile Ge barriers,

(d) a strain-relieved capping layer of $\text{Ge}_{1-y}\text{Sn}_y$ that matches the VS composition,

(f) metallic electrical contacts to the Si substrate and/or capping layer.

-- 11. (Amended) the photodetector devices of claim 10 wherein the VS and cap and quantum wells are doped N type 0. --

-- 12. (Amended) the photodetector devices of claim 10 wherein the VS and cap and quantum wells are doped P type. --

—13. (Original) the laser, emitter, amplifier and modulator devices of claim 10 wherein the VS and cap are both doped N-type or both doped P-type for electron injection or for hole injection, respectively. — —

—14. (Original) the laser, emitter, amplifier and modulator devices of claim 10 wherein the resonant tunneling of injected carriers is used between adjacent periods of the active region in the manner of a quantum cascade. — —